Probing the Mysteries of Blindsight

By Roger Lewin

"... Researchers find that some blind people have an unconscious ability to 'see.' Ways are being found to train this vision ..."

Photographed by Ron Walker

Helen was ten when she died. Her brain was taken to an anatomy laboratory, where tiny slices were cut away and prepared for detailed study under the microscope. The analysis confirmed what everyone expected: Only fragments of a vital part of Helen's visual machinery were still intact. And yet, there had been absolutely no doubt that before she died Helen could see.

Helen was a rhesus monkey, and she had been part of a study on the effect of a specific sort of brain damage on the ability to see. In the early 1960s experts found that monkeys are more resistant to physical injury to their visual systems than humans are. Larry Weiskrantz wanted to find out why, so in 1966 he severed the connections to Helen's striate cortex (the first major brain center dealing with vision). "We hoped it might help us in treating brain-injured blind humans."

Helen was blind after the operation. But over the ensuing eight years Weiskrantz, who at the time was working at the Psychology Laboratory in Cambridge, Eng- *(Continued on page 78)*

Roger Lewin is a science writer and co-author of Origins.

Experiments in Vision: The Outer Limits

"If you want to experience what it's like to have a visual-field defect, get two cardboard tubes and hold them up to your eyes. That's what the world looks like to someone with that problem," explains David Longmire, who works with the blind and visually handicapped at the New York Infirmary's Center for Independent Living. Visual-field defects, Longmire says, can have a variety of causes—cataracts, glaucoma, and a gradual shrinking of the sweep of vision called retinitis pigmentosa—but partial blindness from brain damage, usually a stroke, is probably the most devastating. For one thing, it is brutally sudden. For another, when this happens, large chunks of a person's field of vision are blanked out. "These people might lose the left side of vision in both their eyes, for example," Longmire explains, "or everything in the upper left visual field."

Right now, therapy for these problems amounts to training the victim to use what vision he has left. Partially sighted people are taught head scanning—rotating the head from side to side—to compensate for their narrowed view of the world. They are taught to rely on their other senses more, using their hearing more to get a feeling for where they are. Blindsight, Longmire says, or anything like it, is still really too much of an elusive ability to be useful in helping his students.

Uptown from the Center for Independent Living, at Mt. Sinai medical school, a husband-and-wife team of neurologists, Drs. Pedro and Tauba Pasik, are doing similar teaching work which may clear up some of the blindsight mystery. The big difference between their work and Longmire's is that their patients are all brain-damaged blind after surgery and are all monkeys. The Pasiks have been quietly and doggedly pursuing their vision research for the past 25 years. Now, after studying 80 monkeys in their research, they have assembled a fascinating profile of blindsight vision. They found their animals were able to see in a very special way once the striate cortex of each was disconnected, and each could do things like reaching, showing three-dimensional sense. The Pasiks found that this special vision as displayed by their blind monkeys may be even more sophisticated than was originally thought by two British researchers who had discovered a neat distinction between focal and peripheral vision. "We originally found many of the functions of vision remaining after we cut the striate cortex," says Dr. Pedro Pasik. "We just didn't find their vision so neatly compartmentalized." Their monkeys were able to perform tests that required increasingly subtle visual abilities. The animals were at first able to distinguish between bright and dim shapes. They could be trained to tell the difference between a circle and triangle and in one test were able to pick out identical shapes by their colors—either red or green.

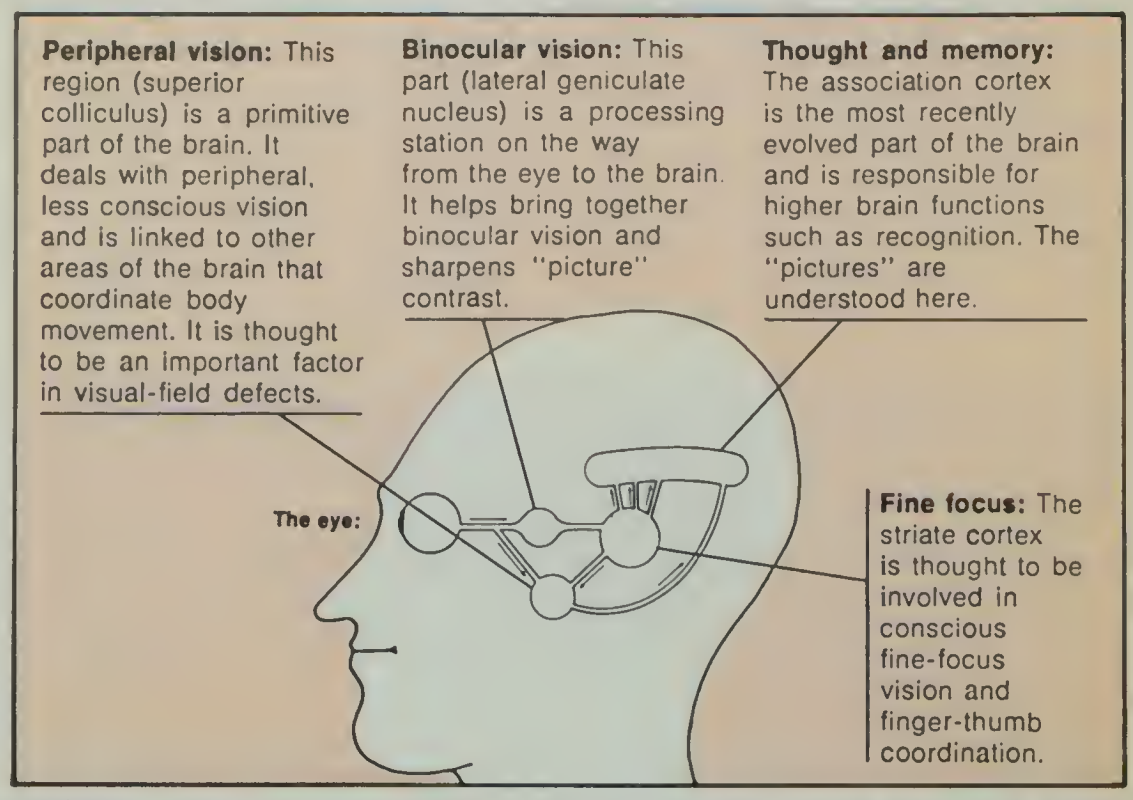
The Pasiks are now involved in trying to find the limits of this vision through even more sophisticated experiments. They have one in which they test how well their "blind" monkeys can tell when the vertical line forming half of a 90-degree angle deviates from a true 90 degrees. Monkeys who had full vision were able to spot the difference within three degrees of pure vertical. Using the hands of a clock as a model, this is the difference between three o'clock and half a minute after three. The blinded monkeys were able to spot this difference within 17 degrees of true vertical, which would be about three minutes past three on the clock.

All of this careful, painstaking work on what blinded rhesus monkeys can and cannot see has effects far beyond the ivory-tower environment of pure research, for, as Dr. Pedro Pasik points out, "the visual system of the monkey is almost identical to that of humans."

That "almost" can make a critical difference, as Dr. William Dobelle of Columbia University points out. Now director of the Division of Artificial Organs, Department of Surgery, Dobelle has become intimately familiar with the human brain's striate cortex as a result of his research in developing an artificial set of eyes—a television-computer relay connected directly to the human brain—for the blind. In one measuring study done on 52 brain hemispheres taken from their autopsied owners, he found that the size of the striate cortex in one brain could be as large as three times the size of another's. For that reason, Dobelle says, it would be hard to generalize about blindness in humans from brain damage: "Our data indicates that the 'textbook brain' is very rare."

In spite of that, tests done at the Massachusetts Institute of Technology showed that monkeys are not alone in having blindsight. Dr. Richard Held, head of MIT's psychology department, decided to see how well it is developed in people. He invited to his laboratory four people who had blind spots, called scotomata, in their fields of vision because of brain damage. He carefully mapped out the blind spots of each and had each person sit in a chair with his head resting comfortably fixed in a chin rest.

The people were told that at the end of a buzzer a moving flashing light would be projected on a wall in front of them in their blind areas.



Blindsight: *Focal vision goes almost directly from the eye to the visual cortex. Peripheral vision plunges to a more primitive part of the brain before reaching the cortex. Some brain-damaged blind people can "see" via this pathway.*

Their instructions were to guess where the light was and follow it with their eyes. Even though some were confused by the request—one asked, "How can I look at something I haven't seen?"—all were uncannily accurate in tracking the moving light. None of them, however, claimed to be aware of any light and all believed their accuracy was just luck.

In spite of these successful experiments, done back in the early 1970s, Held today is careful about making any sweeping generalizations about his findings. "There are lots of blind or partially blind people and they differ in many ways. We still don't know enough to come to any strong specific conclusions. We've tested quite a few people with so-called scotomata. Some managed to perform these tests, and others were totally incapable. So one needs to be cautious."

Part of the problem is sorting out those who have this vision and those who don't. One promising solution is a special booth devised by Pennsylvania State University psychologist Dr. Herschel Leibowitz as the result of his work with the blind and partially blind. He too noticed that some of them seemed to have a special gift of vision. "If you ask whether they see a wall to their side, they will say no; yet they can move around without walking into it," he says. "They don't realize they are still seeing something because the ambient system is so unconscious."

The test Leibowitz devised for this uses a small round platform with a chair sitting on it. This is enclosed in a tall cylinder the inside walls of which are painted in bold black and white vertical stripes. When a normally sighted person sits in the chair and the walls of the cylinder are rotated around him, the effects of the stripes flicking by the edge of his visual field make him feel as though he were moving. When Leibowitz took patients with visual-field defects, blocked out all but their blind spots, and put them in his striped booth, some of them came out swearing they felt as though they were moving without really being able to explain why.

Encouraged by his initial results, Leibowitz believes his striped-booth test could be a simple way of sorting out those who have the power of blindsight from those who don't. And it could give some of David Longmire's students the chance to borrow back some of the vision they thought they had lost. **—Douglas Colligan**

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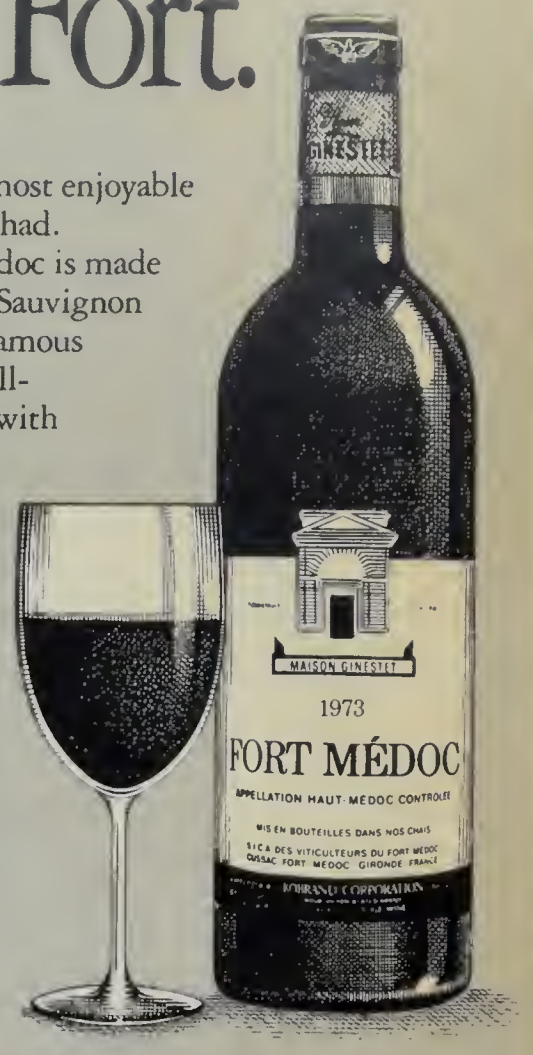

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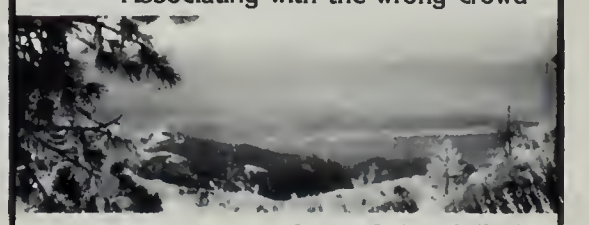

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(Continued from page 75) land, watched with amazement as she gradually began to recover her sight. There was something distinctly odd about Helen's vision. Nonetheless, it was vision. Appropriately enough, Weiskrantz has called this phenomenon "blindsight."

Helen's "recovery" was the beginning of a series of discoveries about blindness. Some of these involve a man who, while he is unaware of it, even denies it, is quite demonstrably able to "see" in an area of his visual field that was thought to be totally blind. He, like Helen, has lost part of the visual apparatus in his brain.

Blindsight appears to be an unconscious phenomenon that can be trained through practice to become a more conscious tool. Right now it seems that this incipient "vision" is a feature of only one type of blindness—visual-field defects—but research into the numerous different physical causes of blindness is still very much in its infancy, and it is quite possible that further exploration will find blindsight in other types of brain-damage blindness. Researchers, as we shall see (see box on page 76), are already engaged, with some success, in the happy mission of finding ways of sorting out which blind people are harboring this secret vision.

First, let's hear more about monkey Helen. She was taken care of by a young psychologist, Nick Humphrey. Humphrey was helping Weiskrantz in his experiments and recalls that "immediately after the operation Helen appeared to be quite blind, and during the next year she showed little sign of any vision." Then, just over a year after the operation, Humphrey noticed something odd: Helen appeared to turn her eyes to look at moving objects.

Humphrey encouraged this looking response by giving food rewards, and Helen soon learned to reach out for the objects she saw. After ten months she could detect stationary objects as well as moving ones. Very soon "her performance improved to such a degree that she became capable of reaching quickly and accurately for small distinct spots . . . her psychophysical thresholds were almost comparable with those of a normal monkey," Humphrey remembers. She could reach for a spot no more than a millimeter wide and distinguish between a spot of ten millimeters and one of eight millimeters.

But Helen still could not use her eyes in a normal way. Humphrey: "Though she would scan the world with her eyes, she seemed to make no sense of what she saw." Then something truly novel happened. In 1970, Humphrey abandoned tests with Helen but began to put a leash on his monkey

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and take her for walks in the Cambridge countryside. "At first these walks were fairly hazardous," he recalls. "Helen continually collided with obstacles, bumped into my legs, and several times fell into a pond." She quickly learned to skirt around obstacles, and then began to approach objects to look at and feel them. She even developed an attachment for an old elm tree; she would climb it and then perch in a hole in its trunk. While she was up there, Humphrey handed her bits of fruit. And it was then, after about eight months of these sylvan adventures, that he noticed something very important: If he held the fruit just out of Helen's reach, she didn't bother to try to get it, where previously she had reached out every time, whether the fruit was near enough or not. Helen was clearly creating a three-dimensional world for herself, a world that depended on quite sophisticated visual abilities.

But Helen had some rather strange shortcomings. For instance, in less than a minute, she could pick up 25 currants scattered on the floor between variously shaped objects, but if there was a small piece of black tape stuck to the floor among the currants, Helen would return to it again and again, trying to pick it up. It seems that she could not remember what things were or identify them by their position—she could not create a map in her head.

And another curious thing was the way she used her hands: Instead of making use of the precision finger-thumb grip, with which evolution has equipped the higher primates, Helen always picked up objects with a palm-and-four-finger grip. It was as if she had become more "primitive" somehow. Humphrey believes that Helen's recognition machinery wasn't functioning either. He laments that "after six years she still does not know a carrot when she sees one, nor apparently does she recognize my face."

The case of Helen the rhesus monkey is both fascinating and extremely puzzling: "In one sense she sees everything; in another sense, nothing" is Humphrey's enigmatic comment.

When Weiskrantz embarked on the investigation with Helen, he wanted to explore a clinical situation in brain-injured humans, which involves visual-field defects—blind areas in an otherwise normal visual span. In the United States at the moment, there are upwards of 200,000 people with visual-field defects, the result of stroke, brain tumor, or physical damage to the visual region of the brain (the part at the back of the head).

The results with Helen generated tremendous excitement: "Before the ex-

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"...Though clinically blind in his left visual field, D.B. could see things in it..."

Helen: *This rhesus monkey, experimentally blinded by a brain operation, learned to "see" well enough to pick up 25 scattered currants in under a minute.*

periments with Helen and other monkeys, we simply did not know how to do the tests on visual-field patients . . . the results with Helen showed us how to ask the right questions." Weiskrantz set out in search of a "model" patient to whom he could pose these questions.

As luck would have it, D.B., a young man in his thirties, was recovering from a brain operation which was performed to relieve terrible headaches. They were caused by a malformation in the blood supply to the back part of his brain, the area responsible for sight.

The surgeon knew that the operations he was to perform on D.B. would sweep away half of his patient's visual apparatus: D.B. would be able to see things to his right if he kept his eyes fixed ahead of him, but nothing to his left—his left visual field would be blind, or so the doctors thought.

D.B. was willing to be tested and arrangements were made rapidly. Weiskrantz started testing with three other doctors: Elizabeth Warrington, a researcher at the National Hospital in London; Michael Sanders, a consultant looking after D.B. at the hospital; and the third doctor, J. Marshall. It quickly became glaringly obvious that, although clinically blind in his left visual field, D.B. could "see" things in it. For instance, the researchers asked him to point to a source of light which they flashed briefly in his left field; this he did with uncanny accuracy. And he was able to distinguish between two parallel lines shown only in his left field with almost as much precision as in the good right field.

Throughout the testing, Weiskrantz and Warrington simply asked D.B. to do this task or that, without telling him the result. At the end of it all, the researchers told D.B. how accurately he had performed, and he was astonished. "I was just guessing," he said. But he had gotten too many right answers for that. Yet he wasn't conscious of seeing the test symbols either.

Weiskrantz says that he pressed D.B. hard on how he made decisions during the tests: "He was very reluctant to use words in any firm way at all. He denied seeing anything and said he had 'feelings,' say, of smoothness when presented with a circle and jaggedness if it were a cross." Whatever these "feelings" are, they certainly have very little to do with visual consciousness as we know it. How can it be explained?

The answer may be contained in an idea that was dreamed up during an afternoon seminar by four researchers—Gerald Schneider, David Ingle, Richard Held, and Colwyn Trevarthen—at MIT in the late 1960s. They created what has come to be known as the "two visual systems" theory. This says that humans and their primate cousins have two modes of vision: one, to help examine the fine detail of objects, a facility linked to the precision finger-thumb manipulation characteristic of the higher primates; and two, a more general

scanning function which alerts us to new objects entering our field of vision. The first is called focal vision, and the second, peripheral, or ambient, vision.

The idea, then, is that focal and peripheral vision have different, though complementary, jobs. It is the signal entering the focal channel that goes to the higher centers of the brain, where it takes part in memory and recognition and other complex intellectual functions. We are very conscious of this. Peripheral vision, on the other hand, is a much less intrusive facility. It is largely an unconscious operation and only makes its presence known if something important happens. Colwyn Trevarthen tells a story which emphasizes this point and demonstrates how closely this part of vision is keyed into automatic body movement:

One day, an employee of the Jet Propulsion Laboratory was driving down a freeway when he noticed a store where he could buy something he needed, but it was on the opposite side. He stopped and set out to walk across the freeway. Suddenly he was flat on his back. "I must be dead," he thought. "I must have been run over."

He started to look around and saw that the road was clear—nothing to be seen from horizon to horizon. So, feeling somewhat foolish and more than a little puzzled, he picked himself up. And then he saw a plane overhead, its shadow speeding down the freeway like a giant automobile; Trevarthen says that the shadow must have been detected in the man's peripheral field of vision, interpreted as an approaching automobile (he was crossing a potentially hazardous freeway after all), and activated an avoidance response, all very rapidly and totally unconsciously.

To achieve a better insight into the JPL man's embarrassing plunge on the freeway, D.B.'s unconscious vision, and Helen's blindsight, we will need to take a brief excursion through the visual pathways of the human brain. Basically, there are two pathways (see diagram, page 76): one which passes directly from the eyes to the first way station in the visual cortex, known as the striate cortex; and a second, which branches off from the first, plunges down to a more primitive part of the brain, and finally climbs up to a higher center of the cortex, where the "pictures" we experience as vision are created. As well as connecting up to the "picture" center, this more primitive part of the brain is also linked in with centers dealing with coordinating body movement. The striate cortex sends messages to the higher "picture" area too, so this area forms the meeting point for the previously diverged paths.

If one thinks of the first path as mediating focal vision, and the second, peripheral vision, it all becomes clear. In her operation, Helen lost the whole of her striate cortex, so the focal vision was effectively eliminated. She was left with ambient vision only, a facility she had to practice extensively before she could make real use of it. The absence of focal vision explains her inability to recognize objects, to form maps in her head, and even her use of the "primitive" palmar grip. You need the detailed focal vision to guide the finger-thumb precision grip.

So far the tests with D.B. are in their early stages, and it may be that he is in the same condition that Helen was soon in after her operation. He is not yet readily conscious of this unusual vision, his blindsight. As the history with Helen showed, however, practice will be vital in transforming his initially useless blindsight into a functional experience. Already, there are signs that D.B. is moving the way Helen did.

"Previously," says Weiskrantz, "we used to ask patients, 'Do you see that?' but such questions were getting us nowhere." He now knows the right questions to ask, and, as he says, because of it, "the whole question of visual-field defects can now go back to square one."

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